

WHAT IS CLAIMED IS:

1. An image processing apparatus for converting a spatial resolution of an original image so as to respectively multiply Z times either in a vertical direction or a horizontal direction or both directions, the image processing apparatus comprising:

energy calculating means for calculating a central pixel energy at a pixel position of interest;

edge enhancement means for enhancing an edge based on the central pixel energy calculated by the energy calculating means;

edge direction detecting means for detecting a direction of the edge enhanced by the edge enhancement means;

linear interpolation means for interpolating a linear interpolated pixel at the pixel position of interest by linear interpolation;

selected direction interpolating means for interpolating a selected direction interpolated pixel in a selected direction at the pixel position of interest based on the edge direction detected by the edge direction detecting means, and

compositing and interpolating means for interpolating a composition interpolated pixel by compositing the linear interpolated pixel and the selected direction interpolated pixel.

2. The image processing apparatus according to Claim 1:

wherein the energy calculating means calculate the central pixel energy in the horizontal or vertical direction of a predetermined pixel of the original image from pixel values of adjacent pixels present in a proximity of the pixel.

3. The image processing apparatus according to Claim 2, further comprising:

maximum and minimum value detecting means for detecting a maximum value and a minimum value of pixel values of pixels that are arrayed in the vertical direction or horizontal direction while having the predetermined pixel at the center, the pixels being included in the adjacent pixels used by the energy calculating means;

first comparing means for comparing the central pixel energy with the minimum value and a predetermined threshold value, the predetermined threshold value

being greater than the minimum value and smaller than the maximum value; and

texture enhancing means for enhancing texture based on the central pixel energy calculated by the energy calculating means;

wherein, if the central pixel energy is found to be equal or greater than the minimum value and smaller than the threshold according to a first comparison result of the first comparing means, the texture enhancing means judges that the predetermined pixel belongs to a texture area and a filter processing is performed to enhance the texture.

4. The image processing apparatus according to Claim 3,

wherein the filter processing is one-dimensional filter processing that is performed by adding products that are obtained by multiplying predetermined filter coefficients and corresponding pixels.

5. The image processing apparatus according to Claim 4,

wherein the predetermined filter coefficient has a value corresponding to the central pixel energy.

6. The image processing apparatus according to Claim 3,

wherein the filter processing is respectively carried out in the vertical direction and the horizontal direction of the original image.

7. The image processing apparatus according to Claim 2, further comprising:

maximum and minimum value detecting means for detecting a maximum value and a minimum value of pixel values of pixels that are arrayed in the vertical direction or horizontal direction while having the predetermined pixel at the center, the pixels being included in the adjacent pixels used by the energy calculating means; and

second comparing means for comparing the central pixel energy with a predetermined threshold value and the maximum value, the predetermined threshold value being greater than the minimum value and smaller than the maximum value;

wherein, if the central pixel energy is found to be equal or greater than the minimum value and smaller than the threshold according to a second comparison result

of the second comparing means, the edge enhancing means judges that the predetermined pixel belongs to an edge area, and a clipping processing is performed after execution of a filter processing to enhance the edge.

- 5 8. The image processing apparatus according to Claim 7,
 wherein the filter processing is one-dimensional filter processing that is
 performed by adding products that are obtained by multiplying predetermined filter
 coefficients and corresponding pixels.
- 10 9. The image processing apparatus according to Claim 8,
 wherein the predetermined filter coefficient has a value corresponding to the
 central pixel energy.
- 15 10. The image processing apparatus according to Claim 9,
 wherein the filter processing is respectively carried out in the vertical direction
 and the horizontal direction of the original image.
- 20 11. The image processing apparatus according to Claim 7, further comprising:
 third comparing means for comparing a pixel value of the pixels subjected to
 the filter processing with the maximum value and the minimum value,
 wherein the clipping processing replaces the pixel value of the pixel subjected
 to the filtering processing with the maximum value if the pixel value of the pixel
 subjected to the filter processing is found to be greater than the maximum value
 according to a third comparison result of the third comparing means, and
25 wherein the clipping processing replaces the pixel value of the pixel subjected
 to the filtering processing with the minimum value if the pixel value of the pixel
 subjected to the filter processing is found to be less than the minimum value according
 to the third comparison result of the third comparing means
- 30 12. The image processing apparatus according to Claim 1,
 wherein the edge direction detecting means comprises:
 edge direction interpolating means for interpolating an edge direction

interpolated pixel for the pixel position of interest,

reliability detecting means for detecting the reliability of the edge direction interpolated pixel that is interpolated by the edge direction interpolating means, and

direction selecting means for selecting an edge direction of a highest reliability
5 based on detection results by the reliability detecting means.

13. The image processing apparatus according to Claim 1,

wherein, if the original image is an interlace image and enlarged twofold in the vertical direction, the compositing and interpolating means interpolates, as the
10 composite interpolated pixel, pixels of a progressive image.

14. An image processing method for converting a spatial resolution of an original image so as to respectively multiply Z times either in a vertical direction or a horizontal direction or both directions, the image processing method comprising:

15 an energy calculating step for calculating a central pixel energy at a pixel position of interest;

an edge enhancement step for enhancing an edge based on the central pixel energy calculated by the energy calculating step;

an edge direction detecting step for detecting a direction of the edge enhanced
20 by the edge enhancement step;

a linear interpolation step for interpolating a linear interpolated pixel at the pixel position of interest by linear interpolation;

a selected direction interpolating step for interpolating a selected direction interpolated pixel in a selected direction at the pixel position of interest based on the
25 edge direction detected by the edge direction detecting step, and

a compositing and interpolating step for interpolating a composition interpolated pixel by compositing the linear interpolated pixel and the selected direction interpolated pixel.

30 15. A recoding medium storing a computer readable program for controlling an image processing apparatus that converts a spatial resolution of an original image so as to respectively multiply Z times either in a vertical direction or a horizontal direction or

both directions, the program comprising:

an energy calculating step for calculating a central pixel energy at a pixel position of interest;

an edge enhancement step for enhancing an edge based on the central pixel energy calculated by the energy calculating step;

an edge direction detecting step for detecting a direction of the edge enhanced by the edge enhancement step;

a linear interpolation step for interpolating a linear interpolated pixel at the pixel position of interest by linear interpolation;

a selected direction interpolating step for interpolating a selected direction interpolated pixel in a selected direction at the pixel position of interest based on the edge direction detected by the edge direction detecting step, and

a compositing and interpolating step for interpolating a composition interpolated pixel by compositing the linear interpolated pixel and the selected direction interpolated pixel.

16. A program for causing an computer to execute a processing, the computer controlling an image processing apparatus that converts a spatial resolution of an original image so as to respectively multiply Z times either in a vertical direction or a horizontal direction or both directions, the processing comprising:

an energy calculating step for calculating a central pixel energy at a pixel position of interest;

an edge enhancement step for enhancing an edge based on the central pixel energy calculated by the energy calculating step;

an edge direction detecting step for detecting a direction of the edge enhanced by the edge enhancement step;

a linear interpolation step for interpolating a linear interpolated pixel at the pixel position of interest by linear interpolation;

a selected direction interpolating step for interpolating a selected direction interpolated pixel in a selected direction at the pixel position of interest based on the edge direction detected by the edge direction detecting step, and

a compositing and interpolating step for interpolating a composition

interpolated pixel by compositing the linear interpolated pixel and the selected direction interpolated pixel.

17. An image processing apparatus for converting a spatial resolution of an original image so as to respectively multiply Z times either in a vertical direction or a horizontal direction or both directions, the image processing apparatus comprising:

direction detecting means for detecting a direction of an edge at a pixel position of interest;

edge direction interpolating means for interpolating an edge direction interpolated pixel at the pixel position of interest based on the edge direction detected by the direction detecting means;

reliability detecting means for detecting a reliability of the edge direction interpolated pixel interpolated by the edge direction detecting means;

direction detecting means for detecting a direction of the edge of a highest reliability detected by the reliability detecting means;

linear interpolation means for interpolating a linear interpolated pixel at the pixel position of interest by linear interpolation;

direction selecting interpolating means for interpolating a selected direction interpolated pixel at the pixel position of interest based on the edge direction detected by the direction detecting means, and

compositing and interpolating means for interpolating a composition interpolated pixel by compositing the linear interpolated pixel and the selected direction interpolated pixel.

18. The image processing apparatus according to Claim 17, further comprising:

consistency determining means for determining consistency of a local structure of the edge direction interpolated pixel interpolated by the edge direction detecting means, wherein

the reliability detecting means detects the reliability of the edge direction interpolated pixel by the edge direction interpolating means based on a result of determination by the consistency determining means.

19. The image processing apparatus according to Claim 17, further comprising:
directional distribution generating means for generating a directional
distribution based on a relationship between the reliability and the edge direction,
wherein

5 the direction selecting means selects an edge direction having a highest
reliability based on the directional distribution.

20. The image processing apparatus according to Claim 19, further comprising:
weighting means for setting a weight of a direction selecting interpolated pixel
10 based on the reliability of a direction having the highest reliability selected by the
direction selecting means from the directional distribution,

wherein the compositing and interpolating means interpolates a composite
interpolated pixel by using a coefficient corresponding to the weight set by the
weighting means and by taking a linear sum of the linear interpolated pixel and the
15 selecting interpolated pixel.

21. The image processing apparatus according to Claim 1,
wherein, if the original image is an interlace image and enlarged twofold in the
vertical direction, the compositing and interpolating means interpolates, as the
20 composite interpolated pixel, pixels of a progressive image.

22. An image processing method for converting a spatial resolution of an original
image so as to respectively multiply Z times either in a vertical direction or a horizontal
direction or both directions, the image processing method comprising:

25 a direction detecting step for detecting a direction of an edge at a pixel position
of interest;

an edge direction interpolating step for interpolating an edge direction
interpolated pixel at the pixel position of interest based on the edge direction detected
by the direction detecting step;

30 a reliability detecting step for detecting a reliability of the edge direction
interpolated pixel interpolated by the edge direction detecting step;

a direction detecting step for detecting a direction of the edge of a highest

reliability detected by the reliability detecting step;

a linear interpolation step for interpolating a linear interpolated pixel at the pixel position of interest by linear interpolation;

5 a direction selecting interpolating step for interpolating a selected direction interpolated pixel at the pixel position of interest based on the edge direction detected by the direction detecting step, and

a compositing and interpolating step for interpolating a composition interpolated pixel by compositing the linear interpolated pixel and the selected direction interpolated pixel.

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23. A recoding medium storing a computer readable program for controlling an image processing apparatus that converts a spatial resolution of an original image so as to respectively multiply Z times either in a vertical direction or a horizontal direction or both directions, the program comprising:

15 a direction detecting step for detecting a direction of an edge at a pixel position of interest;

an edge direction interpolating step for interpolating an edge direction interpolated pixel at the pixel position of interest based on the edge direction detected by the direction detecting step;

20 a reliability detecting step for detecting a reliability of the edge direction interpolated pixel interpolated by the edge direction detecting step;

a direction detecting step for detecting a direction of the edge of a highest reliability detected by the reliability detecting step;

25 a linear interpolation step for interpolating a linear interpolated pixel at the pixel position of interest by linear interpolation;

a direction selecting interpolating step for interpolating a selected direction interpolated pixel at the pixel position of interest based on the edge direction detected by the direction detecting step, and

30 a compositing and interpolating step for interpolating a composition interpolated pixel by compositing the linear interpolated pixel and the selected direction interpolated pixel.

24. A program for causing an computer to execute a processing, the computer controlling an image processing apparatus that converts a spatial resolution of an original image so as to respectively multiply Z times either in a vertical direction or a horizontal direction or both directions, the processing comprising:

5 a direction detecting step for detecting a direction of an edge at a pixel position of interest;

an edge direction interpolating step for interpolating an edge direction interpolated pixel at the pixel position of interest based on the edge direction detected by the direction detecting step;

10 a reliability detecting step for detecting a reliability of the edge direction interpolated pixel interpolated by the edge direction detecting step;

a direction detecting step for detecting a direction of the edge of a highest reliability detected by the reliability detecting step;

15 a linear interpolation step for interpolating a linear interpolated pixel at the pixel position of interest by linear interpolation;

a direction selecting interpolating step for interpolating a selected direction interpolated pixel at the pixel position of interest based on the edge direction detected by the direction detecting step, and

20 a compositing and interpolating step for interpolating a composition interpolated pixel by compositing the linear interpolated pixel and the selected direction interpolated pixel.